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U.S. NAVAL PROVING GROUND
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Director,
Armed Services Technical Inf

U S NAVAL PROVING GROUND
DAHLGREN VIRGINIA

REPORT NO 1148

BOMBS AND ASSOCIATED COMPONENTS

61st Partial Report

- -

MODIFICATION AND TEST OF FIN ASSEMBLY FOR
BOMB G P 1000 LB LOW DRAG TYPE EX 10 MOD 9

FINAL Report

Task Assignment: NFG Re3c 32 1 53

Copy No 11

Classification CONFIDENTIAL
SECURITY INFORMATION

Modification and Test of Fin Assembly for
Bomb, G.P., 1000 Lb. Low Drag, Type EX 10 Mod 9

PART A

SYNOPSIS

1. This is a final report on a test of the Bomb, G.P., 1000 lb. Low Drag, Type EX 10 Mod 9 with a modified fin assembly performed under Task Assignment No. NPG-Re3c-321-1-53. The modification consisted of canting the fins two (2) degrees in a right hand screw direction.

2. This test was conducted to determine:

a. The spin and yaw of the modified bomb during free fall from release to impact.

b. The ballistic coefficients and dispersion of the modified bomb.

c. The presence and extent of vibration when carried externally on high speed aircraft.

3. The results indicate that:

a. The EX 10 Mod 9 Bomb, modified with two (2) degree canted fins, develops a spin rate of approximately 12 r.p.s. at 44 seconds of fall.

b. The yaw of the bomb in the lower part of the trajectory is less than five (5) degrees. The magnitude of initial yaw and rate of damping were not observed.

c. Reciprocal ballistic coefficients for drops from 30,000 feet of the modified bomb are 0.116 for time of fall and 0.086 for range.

d. For drops from 30,000 feet at 140 to 160 knots indicated air speed, dispersion in range and deflection is about 1.5 mils.

e. For drops from 30,000 feet altitude, the average deflection is about three (3) mils to the left.

Modification and Test of Fin Assembly for
Bomb, G.P., 1000 Lb. Low Drag, Type EX 10 Mod 9

- -

4. It is concluded that:

a. The spin induces a slight deflection of the bomb to the left.

b. The bomb, as a result of this modification, has good flight and very small dispersion.

c. The bombs with two (2) degree canted fins when carried externally, do not impart any unusual flight characteristics to propeller driven aircraft at speeds up to 400 knots.

5. It is recommended that:

a. Two (2) degree canted fins be used to stabilize the Low Drag, Type EX 10 Bombs.

b. The two (2) remaining modified bombs be dropped from altitudes at which good ground photographs of the release are possible and at as high an air speed as possible for information on initial yaw and rate of damping of initial yaw. Furthermore, two unmodified bombs be dropped under the same conditions for comparison.

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Modification and Test of Fin Assembly for
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PART B

INTRODUCTION

1. AUTHORITY:

This test was conducted under Task Assignment No. NPG-Re3c-321-1-53 authorized by reference (a) and in accordance with references (b) and (c).

2. REFERENCES:

a. BUORD Conf ltr NP9 Re3c-BEK:mp Ser 42777 of 29 Jul 1952
b. BUORD Conf Spd ltr Re3c-LME:gg F41-6 Ser 47139 of 4 Nov 1952
c. BUORD Rest dispatch Ø52Ø27Z of Dec 1952
d. NPG Conf ltr OVX:BFB:evc A11/3c321-1 Ser 30368 of 9 Feb 1953 to BUORD
e. NPG Conf Report No. 1116 of 29 April 1953

3. BACKGROUND:

a. In a test at the Naval Proving Ground on 26 August 1952 three (3) EX 10 Mod 9 Bombs with tail assemblies manufactured by the Scaife Company of Oakmont, Pennsylvania, were released from an AD-2 type aircraft in horizontal flight at an altitude of 31,790 feet. Indicated airspeeds at time of release were approximately 135 knots. Two (2) of the three (3) bombs developed approximately 35 degrees yaw after falling half way to the ground. One (1) of the bombs maintained this amount of yaw throughout the last half of its trajectory. The yaw of the other bomb damped to about 10° and finally increased again to about 35 degrees at impact. The third bomb did not appear to develop more than five (5) degrees yaw throughout its trajectory. An analysis of the film taken of these drops revealed that the spin rate of the two (2) bombs that developed large yaw was 1.2 and 1.0 revolutions per second at impact. This resulted in spin distances of 720 and 900 feet, respectively. It was noted that the yaw oscillation distances at this time were also 720 and 900 feet, respectively. This relation was considered to be significant. The spin rate of the third bomb near impact was 0.11 revolutions per second and its spin distance was 8,000 feet. Further study of the data taken on other low drag bomb drops revealed that on all drops where the yaw was appreciable, the measured spin distances and yaw oscillation distances were equal.

b. When yaw oscillation and spin distances are equal, "lunar motion" results. This means that as the bomb processes around the velocity vector, the same side of the unit is always presented to the velocity vector. Under these circumstances, if a moment exists, caused by asymmetries in the shape of the unit or from the tail structure, it is constantly directed in the same direction with respect to the bomb and will, if it acts in the proper direction, add energy to the system. This will cause the procession rate and yaw to increase. When the yaw oscillation distance and spin distance are not equal, the direction of the moment continually changes. Thus, part of the time it adds energy and part of the time it removes energy from the system; therefore, it would not lead to an increase in yaw. An example of this is the Mod 9 unit which appeared to have less than five (5) degrees yaw throughout its trajectory and had a spin distance at impact of 8000 feet. Inasmuch as the yaw was very small, the yaw oscillation distance could not be measured; however, the theoretical value calculated was 950 feet. The foregoing is discussed in more detail in reference (e). In view of these facts, it was decided to try canting the fins of a bomb so that the spin distance would be significantly different from the yaw oscillation distance.

c. To accomplish the above, reference (b) requested that twelve of the Mod 9 fin assemblies be modified by canting each fin about the mid point of the root chord to an angle of incidence of 2*1/2 degrees so that a counterclockwise spin is obtained when looking head on at the bomb. It was further requested that these bombs be dropped from 30,000 feet at the highest airspeed attainable with an AD type aircraft and that information on yaw and spin be obtained. Subsequently, it was verbally requested that only eight (8) of the bombs be dropped and that ballistic coefficients and dispersion also be obtained.

d. At the conclusion of this test, reference (c) requested that flight tests be conducted on two (2) of the remaining Mod 9 bombs with canted fins on an F7F type aircraft at the highest attainable speed in sustained flight and dives within the safe limits of the aircraft to determine the presence and extent of vibration. At the conclusion of this phase of the test and as requested by reference (c), the bombs were delivered to Naval Aviation Ordnance Test Station, Chincoteague, Virginia, for tests on an F9F Aircraft. Reference (d) is a partial report to the Bureau of Ordnance on the flight tests. The flight test data are included in this report because of the limited distribution of reference (d).

Modification and Test of Fin Assembly for
Bomb, G.P., 1000 Lb. Low Drag, Type EX 10 Mod 9

4. OBJECT OF TEST:

This test was conducted on the Bomb, G.P., 1000 lb. Low Drag, Type EX 10 Mod 9 with a modified fin assembly to determine:

a. The spin and yaw of each bomb during free fall from release to impact.

b. The ballistic coefficients and dispersion of each bomb.

c. The presence and extent of vibration when carried externally on high speed aircraft.

5. PERIOD OF TEST:

a.	Date of Project Letter (reference (b)) (reference (c))	4 Nov 1952 5 Dec 1952
b.	Date Necessary Material Received	2 Apr 1952
c.	Date Fin Modification Completed	7 Nov 1952
d.	Date Commenced Test	12 Nov 1952
e.	Date Completed Drop Test	1 Dec 1952
f.	Date Completed Flight Test	15 Dec 1952
g.	Date Bombs Deliverd to NACTS, Chincoteague, Virginia	15 Dec 1952

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEM UNDER TEST:

The Bombs, G.P., 1000 lb. Low Drag, Type EX 10 Mod 9 used for this test were of the same type as the bombs used for the tests described in reference (e) with the exception of a simple fin modification. This fin modification consisted of replacing the positioning pins on the base of each fin with pins slightly off the fin base chord centerline. The forward pin was relocated to the right and the rear pin to the left when the fin is viewed from the base. Figure 1 is a base view of a standard and a modified fin. This modification was designed to give the fins a 2-1/2 degree angle of attack with respect to the bomb's longitudinal axis and produce a clockwise spin when the bomb is viewed from the rear. Figures 2, 3, and 4 are views of the tail assembly showing the cant and fit of the modified fins. The bombs have a midsection diameter of 14 inches and a fin span of 19.625 inches. The leading edge of fin is swept back 45° starting 19 inches from the tip of the tail. The trailing edge is 90° to bomb axis and 5.5 inches from the tip of the tail. The length of the tip chord is 7.333 inches. The total length of the bomb is 120 inches.

7. DESCRIPTION OF TEST EQUIPMENT:

a. For taking fin alignment:

(1) A jig composed of supports, strings and plumb bobs for establishing a horizontal reference line over the longitudinal axis of the bomb.

(2) A straightedge and rule for measuring the angle of the fin to the horizontal reference line.

b. For determining free flight characteristics:

(1) An AD-2 type aircraft equipped with radio for communication with a ground control station, an AN/ARW-3 FM transmitter with 1000-cycle oscillator for transmitting bomb release signals to two (2) oscillograph stations, and three (3) Mk 51 bomb racks with microswitches which open when the bombs fall a measured distance and cut off the oscillator.

(2) A theodolite with right angle telescope and a stop-watch at the ground control station for measurement of aircraft ground speed and direction of aircraft.

(3) An AN/ARC-1 VHF radio at the ground control station for communication with the aircraft.

(4) Two (2) 35mm Mitchell chronograph cameras equipped with lenses of 40-inch focal length and mounted on modified Mk 31 Quadruple Machine Gun Mounts. Associated equipment included radio and electronic equipment and gaseous discharge lamps used for registering master timing impulses on the Mitchell camera film. One (1) of the cameras was in the plane of the trajectory and about 2000 yards from the impact area; the other was about 9500 yards from the plane of the trajectory and about 1000 yards up range. During the greater part of each drop the cameras were operated at a rate of 48 frames per second.

(5) A cine-theodolite photo-triangulation system with three (3) Askania cine-theodolites equipped with lenses of 60 cm focal length, two (2) oscillographs, master timing and transmitting equipment, and electronic equipment. The theodolites were located on a base line roughly perpendicular to the aircraft line of flight and 7000 yards long. Photographs were taken by the theodolites at 1/4 second intervals.

(6) AN/FMQ-2 Radiosonde equipment for upper air density measurements and pilot balloons for upper air wind determinations.

c. An F7F-3 type aircraft was used to conduct the high speed vibration and buffeting test.

8. **PROCEDURE:**

a. Fin alignment was checked by placing the bombs horizontally in a cradle and dropping plumb lines at the exact tip of the nose and tail cone. Between these lines and slightly above the bomb, a horizontal longitudinal reference line was run. The bomb was then rotated about its longitudinal axis until the fin to be measured was in a vertical position. The angle formed by a straight-edge laid against the fin and the horizontal reference line was then measured.

Modification and Test of Fin Assembly for
Bomb, G.P., 1000 Lb. Low Drag, Type EX 10 Mod 9

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b. The bomb bodies were filled with a cement-perlite mixture formulated to a specific gravity of 1.65. After filling, the bombs were sealed and the specific gravity of the loading checked. This was done by dividing the differences between the loaded and empty bomb weight by the weight of water held in a typical bomb (262 lbs.). Centers of gravity were located by balancing the bomb on a knife edge after the bombs were loaded and assembled.

c. The eight (8) modified Type EX 10 Mod 9 Bombs used for a determination of flight characteristics were released singly from an AD-2 type aircraft in approximately horizontal flight. The aircraft was flown at a prescribed altitude of approximately 30,000 feet and at a constant air speed toward a ground control station. A theodolite at this station was used in directing the aircraft so that it remained on a prescribed bearing. The ground speed of the aircraft was determined on a dry run by timing the aircraft with a stop watch as it passed through two (2) given elevation angles on the theodolite. The elevation angle to a desired release point was then calculated by using the aircraft altitude and ground speed and the estimated trail and time of fall of the bomb. A voice command transmitted when the theodolite reached this predetermined angle was used to indicate to the pilot that he should release the bomb. The interruption of a tone transmitted by the AN/ARW-3 radio in the aircraft indicated that the bomb had fallen a distance equal to the throw of the microswitch on the bomb rack. This signal was recorded on oscillographs along with theodolite triggering signals and chronograph camera synchronizing signals. Two (2) Mitchell chronograph cameras equipped with 40 inch lenses were used to record spin and yaw of the bombs. The determination of yaw involves measurement of the orientation of the bomb appearing in the film taken by each camera. From these measurements and the relative positions of the cameras and bomb, the orientation of the bomb in three (3) dimensions is calculated and compared with the velocity vector from trajectory calculations. However, since the yaw was very small, the film was only qualitatively examined and the maximum yaw was estimated. Spin rate was determined from the Mitchell photographs by timing the appearance of a longitudinal stripe on the bomb as it rotated. Ballistic coefficients were computed on the basis of theodolite data on the position and velocity of the aircraft at release and of the bomb near impact; in addition, the wind structure and atmospheric density were used. On one (1) drop where the bomb could not be observed before impact, theodolite data on the impact splash was used; the time of the splash was determined from the Mitchell photographs. The ballistic coefficients were adjusted to an average bomb weight of 957 lbs. The dispersions (standard deviation

of an individual observation) in range, and time of fall were calculated from the adjusted ballistic coefficients and dispersion in deflection from observed deflections, corrected for wind and rotation of the earth. Wind data were obtained from two (2) theodolite observations of pilot balloons and density from rasonde observations.

d. High speed flight tests were conducted by suspending two (2) modified bombs from the wing racks of an F7F-3 type aircraft. Dives were started from 10,000 feet to 15,000 feet. Thirty-one (31) dives were made at airspeeds of 340 to 400 knots. A total time of 16 minutes and 21 seconds was accumulated in this manner. In addition to the high speed time, the bombs were flown at airspeeds of 180 to 250 knots for 3 hours and 30 minutes to ascertain the effects of prolonged flight.

9. RESULTS AND DISCUSSION:

a. Fin alignment measurements are tabulated in Table I. All of the individual fins were within the prescribed 2±1/2 degrees cant. Average fin cant angles for the bombs varied from 1 degree and 43 minutes to 2 degrees and 27 minutes. No correlation could be found between the average fin cant angle and the observed spin rate. This is probably because of the limited accuracy of the method used to measure fin cant angles.

b. The average weight of the bombs with tails assembled and filled with a cement-perlite mixture formulated to a specific gravity of 1.65, was 957 lbs. The average center of gravity was 71.70 inches from the tip of the tail and about 1.5 inches forward of the midpoint of the two suspension lugs. General data on bomb loading are contained in Table II.

c. Three (3) bombs were dropped from 30,000 feet on 12 November and five (5) were dropped on 1 December, 1952. The yaw of these bombs was not discernible in the 40" camera chronograph film. It is estimated to have been less than five (5) degrees during the last half of the trajectory. Spin rates, as determined from the Mitchell photographs, are tabulated as a function of time in Table III. The average spin rate was 12 r.p.s. at impact. For Drop No. 6 (1535 on 1 December 1952), the spin distance for each two (2) seconds of fall was computed from the observed velocity relative to the wind. These spin distances are tabulated as a function of time of fall in Table IV. Spin distances were not

computed for the other drops since they would be approximately the same as for this drop. For comparative purposes a theoretical yaw oscillation distance is included in Table IV. From these figures it can be seen that the spin distance is not in close agreement with the theoretical yaw oscillation distance for any appreciable time.

d. The height of these releases (30,000 feet) and the distances of the camera stations prevented detailed observation of the altitude of the bomb for ten (10) to twenty (20) seconds after release. Therefore, information with respect to the magnitude and damping of the initial yaw is not available. It is not known what effect, if any, the canted fins would have on these quantities. Two (2) modified bombs are available in addition to two (2) unmodified bombs which could be used for a comparative study of the flight shortly after release.

e. Reciprocal ballistic coefficients for time of fall and for range for the subject bomb were found to be 0.116 and 0.086, respectively. The mean deflection was found to be 3.0 mils to the left. This deflection was probably caused by the spin of the bomb, which would produce a "yaw-of-repose" to the left of the velocity vector. Table V contains the ballistic data for each drop. The values obtained for the dispersion in time of fall, range and deflection for drops from 30,000 feet at 140 knots indicated airspeed were 0.07 seconds, 1.5 mils and 1.8 mils, respectively. These values are not much larger than the uncertainties caused by the errors of measurement. Table VI shows a comparison of these results with the results obtained for other modifications of the EX 10 type bomb.

f. Speeds up to 400 knots were sustained in the flight endurance tests with the modified bomb on the F7F-3 type aircraft with no unusual flight characteristics. There was no visual damage to the tail assemblies after this test. A tabulation of flight times and speeds is contained in Table VII.

PART D

CONCLUSIONS

10. It is concluded that:

a. The spin induces a slight deflection of the bomb to the left.

b. The bomb, as a result of the canted fin modification, has good flight and very small dispersion.

c. The bombs with two (2) degree canted fins, when carried externally, do not impart any unusual flight characteristics to propeller driven aircraft at speeds up to 400 knots.

PART E

RECOMMENDATIONS

11. It is recommended that:

a. Two (2) degree canted fins be used to stabilize the Low Drag, Type EX 10 Bombs.

b. The two (2) remaining modified bombs be dropped from altitudes at which good ground photographs of the release are possible and at as high an airspeed as possible for information on initial yaw and rate of damping of initial yaw. Furthermore, that two (2) unmodified bombs be dropped under the same conditions for comparison.

Modification and Test of Fin Assembly for
Bomb, G.P., 1000 Lb. Low Drag, Type EX 10 Mod 9

- -

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CONFIDENTIAL NPG REPORT NO. 1148

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Sixty-first Partial Report

on

Bombs and Associated Components

- -

Final Report

on

Modification and Test of Fin Assembly

for

Bomb, G.P., 1000 Lb. Low Drag, Type EX 10 Mod 9

Project No.: NPG-Re3c-321-1-53 Date: JUL 29 1953
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NP9-62379 4 November 1952 CONFIDENTIAL
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Fins for Bomb, G.P., 1000 lb., Low Drag, Ex 10 Mod 9, standard (left) and modified (right) showing change in location of positioning pins.

4 November 1952

CONFIDENTIAL
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Fin Assembly for Bomb, G.P., 1000 lb., Low Drag, Ex 10 Mod 9, rear view showing fit and cant of modified fins.

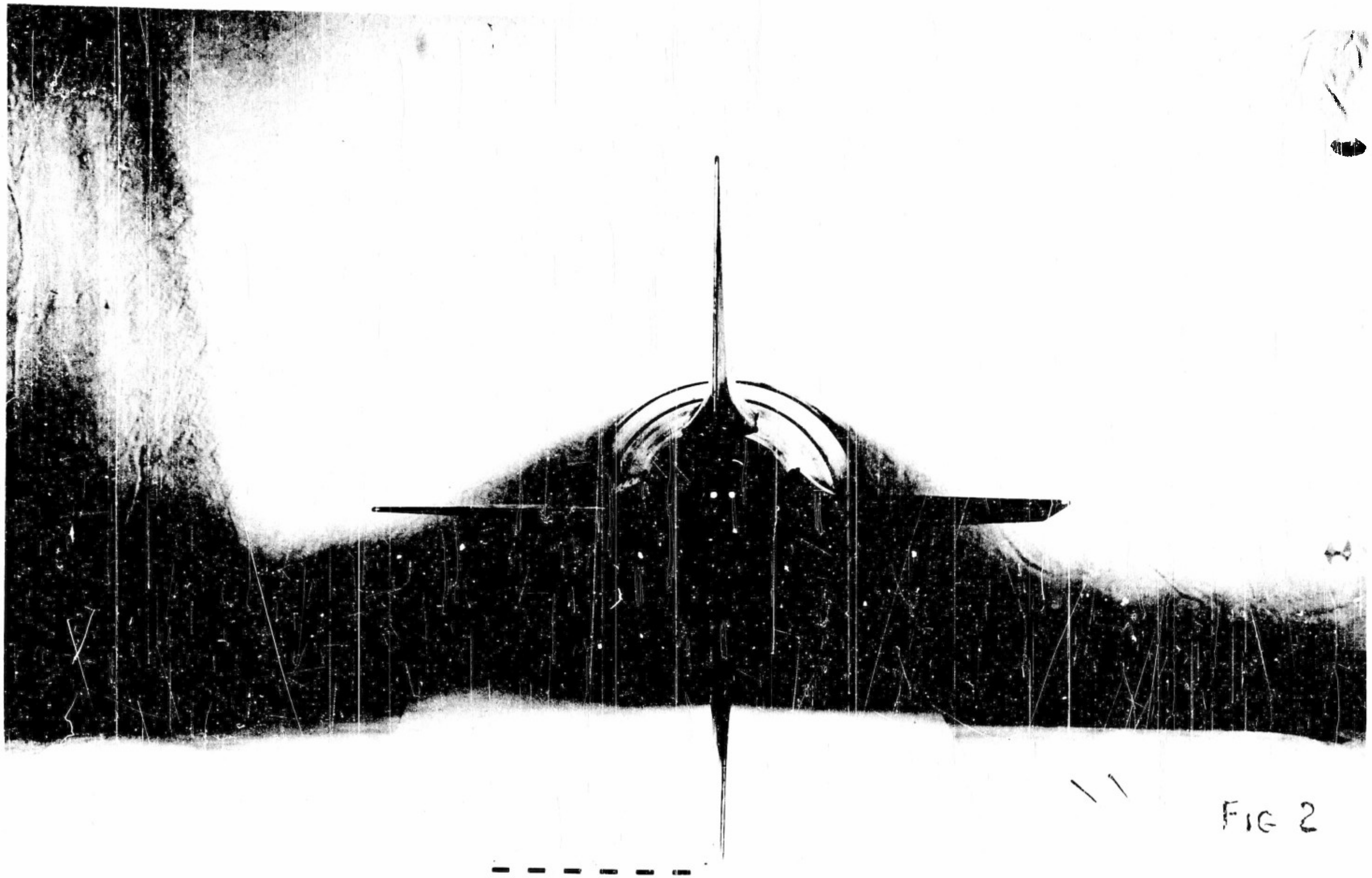

FIG 2

NP9-62381 4 November 1952 CONFIDENTIAL
SECURITY INFORMATION

Fin Assembly for Bomb, G.P., 1000 lb., Low Drag, Ex 10 Mod 9, side view showing fit of modified fins.

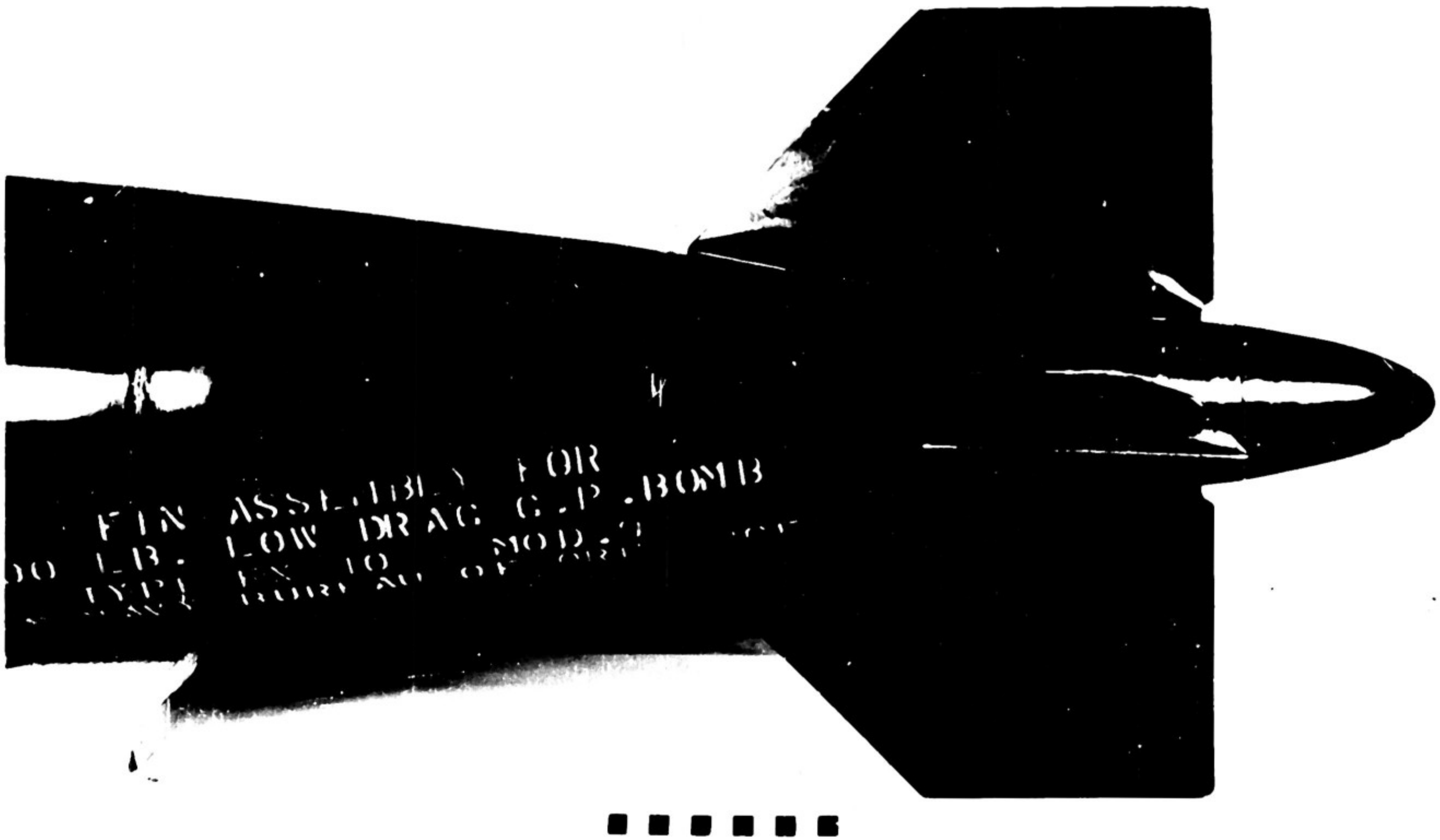

Fig. 2

NP9-62382 4 November 1952 CONFIDENTIAL
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Fin Assembly for Bomb, G.P., 1000 lb., Low Drag, Ex 10 Mod 9, rear view showing fit of modified fins.

FIG. 4

Modification and Test of Fin Assembly for
Bomb, G.P., 1000 Lb. Low Drag, Type EX 10 Mod 9

TABLE I

FIN ALIGNMENT

Drop No.	Bomb No.	Fin		Alignment (degrees—minutes)
1	314	Top Right		2 - 23
		Bottom Right		2 - 20
		Bottom Left		2 - 37
		Top Left		2 - 29
			Average	2° 27'
2	320	Top Right		1 - 49
		Bottom Right		1 - 49
		Bottom Left		1 - 55
		Top Left		1 - 55
			Average	1° 52'
3	328	Top Right		2 - 34
		Bottom Right		2 - 18
		Bottom Left		2 - 29
		Top Left		2 - 06
			Average	2° 22'
4	321	Top Right		1 - 41
		Bottom Right		1 - 37
		Bottom Left		2 - 02
		Top Left		1 - 44
			Average	1° 46'
5	319	Top Right		1 - 44
		Bottom Right		1 - 51
		Bottom Left		1 - 41
		Top Left		1 - 51
			Average	1° 47'
6	330	Top Right		1 - 41
		Bottom Right		1 - 41
		Bottom Left		1 - 37
		Top Left		1 - 55
			Average	1° 43'

TABLE I (Continued)

Drop No.	Bomb No.	Fin		Alignment (degrees—minutes)
7	323	Top Right		1 - 55
		Bottom Right		1 - 48
		Bottom Left		1 - 53
		Top Left		1 - 56
			Average	1° 53'
8	322	Top Right		2 - 06
		Bottom Right		2 - 23
		Bottom Left		2 - 16
		Top Left		1 - 41
			Average	2° 06'

- -

TABLE II

GENERAL DATA ON BOMB LOADING

Drop No.	Bomb No.	Empty without Tail Assembly	Loaded without Tail Assembly	Loaded with Tail Assembly	Weight of Filler (lbs)	Sp. Gr. of Filler	C.G. from Tail (inches)
1	314	465	906	964	420	1.61	71.70
2	320	478	906	955	428	1.64	71.68
3	328	470	900	949	426	1.63	71.75
4	321	488	921	969	433	1.65	71.50
5	319	483	919	968	436	1.66	71.75
6	330	483	914	962	431	1.65	71.65
7	323	482	911	959	429	1.64	71.72
8	322	469	887	935	418	1.60	71.62

TABLE III

SPIN RATE IN RPS AS A FUNCTION OF OBSERVED TIME OF FALL AND ESTIMATED[1] VELOCITY

Time of Fall (sec.)	Drop 1 12 Nov 1227	Drop 2 12 Nov 1238	Drop 3 12 Nov 1245	Drop 4 1 Dec 1510	Drop 5 1 Dec 1519	Drop 6 1 Dec 1535	Drop 7 1 Dec 1621	Drop 8 1 Dec 1630	Estimated[1] Velocity (ft/sec)
0	0	0	0	0	0	0	0	0	440
2	.18	.18	.25	.17	.19	.17	.14	.17	450
4	.37	.37	.48	.33	.37	.35	.29	.31	460
6	.55	.52	.70	.50	.51	.56	.43	.49	480
8	.76	.72	.95	.69	.68	.79	.61	.68	510
10	.98	.92	1.22	.89	.87	1.02	.82	.89	540
12	1.23	1.17	1.51	1.11	1.08	1.28	1.07	1.12	580
14	1.51	1.41	1.82	1.39	1.35	1.57	1.32	1.38	620
16	1.82	1.70	2.17	1.69	1.65	1.87	1.63	1.63	670
18	2.20	2.05	2.52	2.07	2.00	2.18	1.98	2.00	720
20	2.62	2.43	2.92	2.47	2.40	2.55	2.36	2.39	770
22	3.08	2.88	3.37	2.91	2.84	2.93	2.78	2.81	820
24	3.59	3.41	3.84	3.42	3.34	3.40	3.21	3.26	870
26	4.18	3.99	4.38	3.99	3.91	3.93	3.71	3.79	920
28	4.81	4.68	4.98	4.61	4.52	4.56	4.27	4.36	970
30	5.51	5.41	5.62	5.30	5.19	5.30	4.88	4.98	1020
32	6.24	6.21	6.33	6.07	5.92	6.10	5.57	5.64	1070
34	7.02	7.06	7.11	6.87	6.69	6.98	6.31	6.38	1110
36	7.88	7.97	7.97	7.77	7.52	7.88	7.12	7.19	1140
38	8.78	8.92	8.88	8.69	8.44	8.83	8.01	8.11	1180
40	9.77	9.94	9.88	9.68	9.51	9.83	8.98	9.12	1210
42	10.84	11.03	10.98	10.76	10.71	10.88	9.98	10.30	1230
44	12.03	12.19	12.19	11.87	12.14	11.95	11.09	11.70	1260

[1] Assuming an indicated air speed at release of 160 knots and the same wind from the surface to 30,000 feet.

TABLE IV

SPIN AND YAW OSCILLATION DISTANCE AS A FUNCTION OF TIME OF FALL

Drop No. 6, released at 1536 on 1 December 1952

Time of Fall (seconds)	Spin Distance (feet)	Theoretical Yaw Oscillation Distance* (feet)
2	2570	1510
4	1280	1500
6	817	1490
8	628	1480
10	526	1470
12	454	1460
14	399	1440
16	356	1410
18	320	1390
20	291	1360
22	265	1340
24	242	1310
26	222	1270
28	208	1240
30	186	1210
32	170	1170
34	156	1130
36	144	1100
38	133	1060
40	124	1020
42	116	980
44	109	950

* Computed neglecting the effect of spin on the yaw oscillation distance.

TABLE V

BALLISTIC DATA

Drop No.	Date	Time	Release Altitude ft.	Indicated Air Speed kts.	Reciprocal Bal. Coef.[1] Time	Reciprocal Bal. Coef.[1] Range	Deflection[5] mils
1	11/12/52	1227	30568	150	.109	.097	-0.9
2	11/12/52	1238	30332	160	.115	.106	-5.3
3	11/12/52	1245	30258	160	.112	.084	-4.7
4	12/1/52	1510	-----[2]	150	---[2]	---[2]	---[2]
5	12/1/52	1519	29990	155	.113	.065	-2.1
6	12/1/52	1535	30265	160	.119	.068	-4.5
7	12/1/52	1621	30069	145	.126	.087	-1.2
8	12/1/52	1630	30065	150	.121	.098	-2.1
				Average	.116	.086	-3.0
				Std. Dev.[3]	.006	.015	1.8
			Equivalent of Std. Dev.[4]		.07 sec	1.5 mils	1.8

[1]Adjusted to an average bomb weight of 956.6 lbs.

[2]Release signal failed; no data computed.

[3]Standard Deviation = $\left[\frac{\Sigma (X_i - \bar{X})^2}{n - 1}\right]^{1/2}$

[4]For bombs released from 30,000 feet at 140 knots indicated air speed.

[5]Adjusted to no wind and non-rotating earth.

TABLE VI

SUMMARY OF BALLISTIC DATA FOR VARIOUS EX 10 BOMBS*

Bomb	Approximate Rel. Alt. feet	Reciprocal Ballistic Coefficients		Average Deflection mils	Dispersion			No. of Bombs with Yaw > 5°
		Time	Range		Time sec.	Range mils	Deflection mils	
EX 10	20,000	.114	.107	0.3	.06	2.3	1.4	0
EX 10 Mod 1	20,000	.119	.126	-0.9	**	**	**	0
EX 10 Mod 2	20,000	.124	.124	-0.4	.09	3.1	4.1	2
EX 10 Mod 4	15,000	.118	.109	-1.1	.08	1.9	2.2	0
EX 10 Mod 4	30,000	.106	.126	-1.0	.16	1.3	2.7	0
EX 10 Mod 5	15,000	.143	.117	-1.6	.03	1.1	2.5	0
EX 10 Mod 5	30,000	.202	.122	0.2	.95	5.2	2.5	4
EX 10 Mod 9 with Canted Fins	30,000	.115	.085	-3.0	.07	1.5	1.8	0

* All data adjusted to a bomb weight of 966 pounds.

** Not computed; data obtained on only two (2) or three (3) drops.

TABLE VII

FLIGHT TEST

Flight	No. Dives	Dive Speed (kts)	Dive Time (min-sec)	Cruise Speed (kts)	Cruise Time (min)	Remarks
1	0	0	0-00	250	48	No Buffeting-No Vibration
2	3	360	1-15	200	15	"
	3	400	1-15	250	15	"
3	2	350	0-50	200	24	"
4	3	360	1-12	180	15	"
	3	375	1-09	200	15	"
5	8	340	6-00	200	18	"
6	5	360	2-40	200	30	"
7	4	350	2-00	200	30	"
Totals	31 dives		16 Min-21 sec		3 hrs 30 min	

Modification and Test of Fin Assembly for
Bomb, G.P., 1000 Lb. Low Drag, Type EX 10 Mod 9

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